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Factsheet

AIR POLLUTION IN GREENHOUSES

(Replaces Factsheet "Air Pollution Problems in Greenhouses", January 1978)

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Air pollutants may injure greenhouse crops, causing either visible leaf injury symptoms or reduction in plant growth rates or both. The air pollutants may originate within the greenhouse or from exterior sources. Air-pollutant sources within the greenhouse are the direct-fired unit heaters or carbon dioxide (CO_2) generators which burn hydrocarbon fuels. Pesticides, herbicides, and wood preservatives, if misused, may also act as air pollutants. Air pollutants entering the greenhouse from outside may include fumes from industrial plants, heating systems in the vicinity, or vehicles with the engines running. The incidence of some forms of air pollutant injury to greenhouse crops is increasing as more growers use double plastic and other forms of greenhouse sealing to reduce energy loss from natural ventilation.

PLANT SUSCEPTIBILITY TO POLLUTANTS

Plant susceptibility to most pollutants generally varies with age of plant and leaf, time of day, amount of light, temperature, humidity, CO_2 concentration, water supply and nutrient availability. With so many variables affecting plant sensitivity, it is easy to understand why pollutants may be injurious at one time but not another. Most pollutants enter the plant leaves through the pores or stomates on the leaf surface, so conditions such as high atmospheric humidity and good water supply, which favor the opening of stomates, will enhance injury. Water stress, for example, which may result in closing of the stomates, makes plants more resistant to pollutants.

Species vary widely in pollutant sensitivity, and a species sensitive to one pollutant may be tolerant of another. There also may be considerable variation in susceptibility among cultivars within a species.

POLLUTANTS OF CONCERN

Sulfer Dioxide (SO_2)

This pollutant is potentially very injurious to plants and is considered the pollutant most likely to be encountered. Significant sources of SO_2 are direct-fired heaters and CO_2 generators within the greenhouse, as well as boiler houses or nearby industrial emissions. The extent of SO_2 pollution is mainly determined by the sulfur content of fuel because sulfur is converted to SO_2 in the burning process. Other possible sources of SO_2 are overheated sulfur pots or sulfur bombs used for mildew control in the greenhouse.

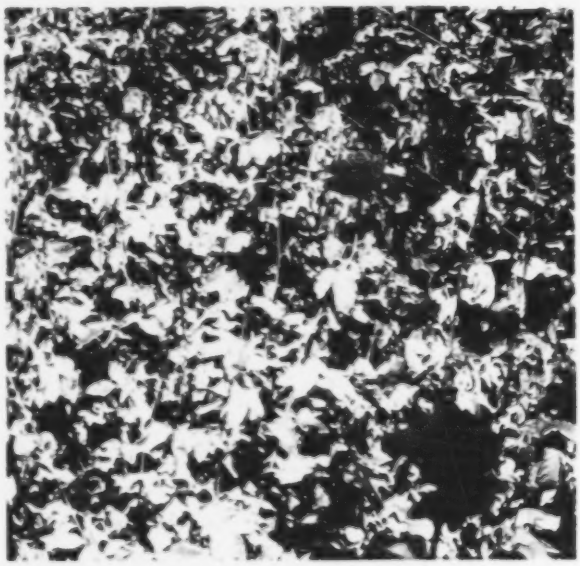

Figure 1. Severe sulfur dioxide injury on roses.

Once SO_2 enters the mesophyll tissue through the stomates of the leaves, it is exposed to many chemical processes associated with living organisms. It reacts with water to produce sulfuric acid, which, in excess, is toxic. The difference between acute SO_2 injury and chronic SO_2 injury depends on the rate of accumulation of SO_2 in the leaves.

Acute SO_2 injury, which occurs as a result of exposure to relatively high concentrations of SO_2, is characterized by severe leaf burn with a distinct line between affected and non-affected tissues. Young leaves seem to be more susceptible. These dead or necrotic areas range in color from ivory to brown depending on the species and environmental conditions (Figure 1). Chronic injury resulting from long-term low-concentration exposure to SO_2 may result in flecking and general chlorosis, and leaves may drop prematurely. This is commonly encountered when sulfur generation coincides with CO_2 supplementation using CO_2 heaters in a greenhouse or when insufficient time is allowed for the sulfur vapors to escape from the greenhouse.

The sulfur vapor present in the air is combusted indirectly with the CO_2 generation process. Sulfur dioxide injury may result in decreased growth and yield, as well as impaired visible appearance and reduced consumer acceptability. Crops such as radish, lettuce, and tomato are more susceptible to SO_2 than chrysanthemum, and carnation.

Ethylene and Propylene

Another common pollutant in greenhouses is ethylene (C_2H_4). Ethylene is a gaseous compound and has a hormonal function in the plant. It regulates vital functions such as seed germination, induction of root growth, promotion of flowering, and leaf abscission. Normally plants produce all the ethylene required for their growth and development processes.

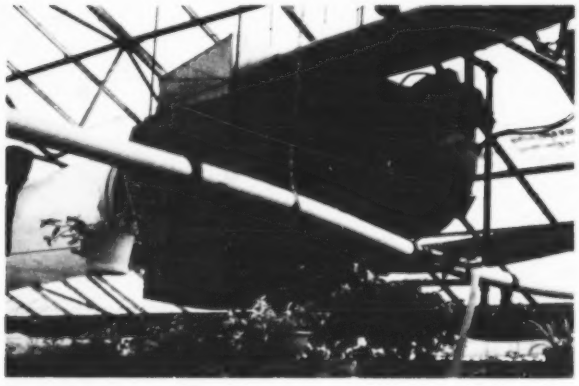

Figure 2. Non-ventilated unit heaters – often a source of pollution.

Injury due to ethylene arises from the use of non-ventilated unit heaters (Figure 2), improperly adjusted burners on CO_2 generators, the exhaust of vehicle engines in or near a greenhouse, or even from ripening fruit.

Ethylene injury includes general reduction in growth, shortening and thickening of stems with proliferation of side shoots (chrysanthemum) (Figure 3), bending and twisting of stems (tomato) (Figure 4), premature leaf and flower-petal drop (marigold), prevention of flower development (sleepiness of carnation), terminal bud abortion and proliferation of side shoots (petunia), withering of sepals (orchid), leaf and flower irregularities (tulip and narcissus), and very short stems with palm tree-like leaf arrangement (lily).

Concentrations of ethylene in the air below 0.01 ppm generally have no effect on plant growth. However, levels of 0.20 ppm and higher for prolonged periods of time will have a detrimental effect. Continuous venting to reduce temperature and concentration is a practical way to minimize the ethylene damage. Another possibility is ethylene scrubbers such as activated charcoal or permanganate solutions. Scrubbers are only useful in closed environments such as coolers or wrapping boxes.

Propylene (C_3H_6) causes ethylene-like responses. The concentrations required for growth responses are usually about 100 times higher than those for ethylene. Propylene may be included in commercial propane and will enter a greenhouse from leaky pipes or faulty burners.

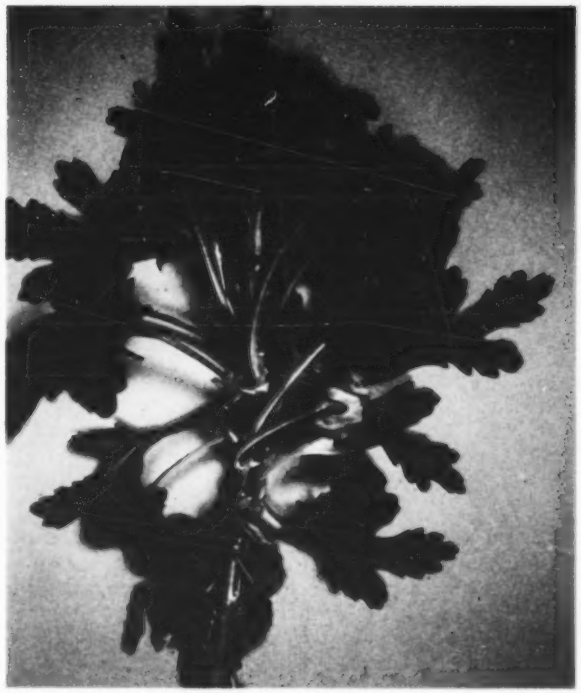

Figure 3. Ethylene injury on chrysanthemums.

Figure 4. Ethylene injury on tomato.

Nitrogen Oxides

Nitrogen oxides include nitric oxide (NO) and nitrogen dioxide (NO_2). They are also produced by direct-heating burners and CO_2 generators but they are usually considered to be less important than other gaseous pollutants. Nitric oxide and NO_2 are produced as a result of a heat-promoted combination of atmospheric nitrogen and oxygen.

Nitrogen dioxide pollution seldom causes direct plant injury. Generally, symptoms of NO_2 injury are darker green leaves, downward-curling leaf margins, and in severe cases, dead areas on the leaves similar to those characterizing acute SO_2 injury. Photosynthesis can be reduced up to 25%, fruit yield reduced, and leaf drop increased with longer-term lower concentrations of NO_2 than those producing visible tissue injury. Most of the available information on the effects of nitrogen oxides concerns NO_2, and little is known of plant response to NO. Tomato is considered to be sensitive to both NO_2 and NO.

Oxidants

Ozone (O_3) and other plant-injuring oxidants are produced outdoors by reactions of nitrogen oxides and other urban and industrial emissions in the presence of sunlight. The mixture of oxidants and their precursors is called oxidant smog. The atmosphere in a closed greenhouse would be expected to contain no more ozone than the trace amounts present in unpolluted air in the open. The situation could be quite different in the summer when large amounts of air are passed through the greenhouse for ventilation. If a fan-and-pad cooling system is being used, the increased humidity may create an environment more favorable to the development of oxidant injury such as from ozone and peroxyacetyl nitrate (PAN).

Symptoms of oxidant injury may include mottling or flecking, bronzing and necrosis of leaves, with resultant premature leaf drop and decreased growth. Oxidant injury symptoms vary greatly depending on species and environmental factors. Weather fleck of tobacco is an example of injury due to ozone air pollution.

Unburned Fuels

Unburned hydrocarbon fuels from direct-fired heaters or burners for CO_2 generation are also a hazard. Even fuels with low levels of sulfur or other impurities can cause plant injury if they escape unburned into the air. This will occur if the burner operation is faulty or the pipe fittings are leaking.

Mixtures of Pollutants

There is ample evidence that mixtures of pollutants which often occur together in the atmosphere, such as SO_2 and NO_2, or SO_2 and ozone, may be more injurious than the single gases. Interactions have been reported in which injury has occurred as a result of mixtures when neither pollutant alone, at the same concentration, would cause injury.

Herbicides and Pesticides

The misuse of herbicides and pesticides often results in plant injury. Volatilization of herbicides applied under benches can be particularly harmful. The concentration of volatiles can build up easily to toxic levels, especially during the fall when the ventilation in the greenhouses is limited. No precise relationships between air concentrations of pollutants and sensitivity of vegetation are presently known. Herbicides with a hormone-like action like 2,4-D or 2,4,5-T cause twisting, cupping of the leaves, excessive elongation and general distortion of sensitive plants (Figure 5).

In general, the use of herbicides should be very limited in the greenhouse and restricted to recommended materials applied at low pressure. Even paraquat (Gramoxone) can be harmful under special circumstances (Figure 6).

Figure 5. 2,4-D injury on poinsettia.

Figure 6. Suspected paraquat injury on poinsettia (normal on left).

Other Pollutants

Ammonia injury sometimes occurs when fresh animal manures are used in greenhouses without adequate ventilation. Fluoride injury may occur to sensitive plants grown with fluoride-containing water, high rates of superphosphate, or in perlite (Figure 7).

Figure 7. Suspected flouride injury on frond of bird's nest fern (necrotic lesions on margin).

Phthalates are plasticisers used in the manufacture of many rigid or semi rigid plastic products such as PVC piping, plant pots, hoses, and glazing strips. Several cases of plant injury from dibutyl phthalate vapour (the most phytotoxic phthalate) have been reported. These compounds volatilize from the plastic items, so tend to be a problem when the greenhouse temperature is high, particularly if ventilation is not adequate. Cabbage cv. Derby Day is very sensitive to dibutyl phthalate, and may be used as a biomonitor.

Figure 8. Creosote injury to chrysanthemums.

Wood Preservatives

The fumes of the two commonly available wood preservatives, creosote and pentachlorophenol, can be extremely injurious to crops (Figure 8). Susceptibility depends on the plant species and environmental conditions as well as the concentrations in the air of any of these materials.

Only copper naphthanate is recommended as a wood preservative for greenhouse use. Allow at least a week to elapse before placing plants on or near freshly treated wood. Poinsettias are sensitive to copper naphthanate and special care should be taken in tight greenhouses.

CONTROL OF AIR POLLUTION IN GREENHOUSES

The direct or indirect discharge of air pollutants into the greenhouse atmosphere must be prevented as much as possible. The pollutants which constitute a problem in a particular greenhouse operation must be identified and the best practicable methods of control utilized.

In oil-fired or gas-fired heating systems, direct-fired heaters, and CO_2-generator burners, the lowest sulfur-content fuel economically practicable should be used to reduce SO_2 pollution in the greenhouse and vicinity. Burner performance and efficiency should be maintained at a satisfactory level by regular servicing to avoid incomplete combustion resulting in ethylene production and release of unburned hydrocarbon fuels. Insufficient air at the burner will also result in incomplete combustion. It has been suggested that a 300 square meter (3300 sq ft) double-poly house with a 88,000 W (300,000 BTU/hour) unit heater will function only 2 hours if proper louvering to allow infiltration of outside air is not provided. As a rule of thumb, a 6 sq cm (1 sq in) inlet of fresh air is needed for each 1500 W (5,000 BTU/hour) capacity of direct-fired heater or CO_2 generator. Flue gases can escape into the greenhouse environment due to cracks in the heat-exchanger. Symptoms of these problems can be related to ethylene or high CO_2. A good indication of escaping flue gases are high levels of CO_2 in the greenhouse. Leaky fuel-pipe fittings should be repaired to prevent crop injury. Substantial amounts of ethylene and other injurious pollutants are produced at "start-up" and "shut-down" of burners. The risk of crop injury at these times can be minimized by exhausting the flue gases to the outside atmosphere, as well as by regular ventilation of the greenhouse.

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